Electron g factor

HOME: The Physics of Bruce Harvey

The author has put much effort into trying to derive the electron spin g factor of 2.002319304386.

It would have been quite easy to fudge this. The author is of the opinion that the claims of verification of QED through the calculation of:

$$\frac{g}{2} = 1 + \frac{\alpha}{2\pi} + \frac{2}{3}\alpha^2\left(\frac{\alpha}{2\pi}\right) - \frac{4}{3}\left(\frac{\alpha}{2\pi}\right)^2$$

are to say the least over optimistic. If an experiment is to be conducted to verify a theoretical result of this nature, the experimenter should be ignorant of the answer. There is a very simple reason for this. Most experiments do not work first time. The apparatus usually needs a lot of fine tuning and even modification. Months or sometimes years of effort can go into getting an experiment to work satisfactorily. If the experimenter knows the answer, it is all too easy to either unwittingly or wittingly fine tune the apparatus to produce the right result.

The same might be said of a theoretician. The true test only comes when they work in ignorance of the experimental result. It is the author's experience that it is very easy to unwittingly fudge a mathematical derivation through a chance combination of errors.

We should first examine the fine structure constant α so often described as a dimensionless constant. It is in fact the ratio of the speed of an orbiting electron (in Bohr's original model of the hydrogen atom) to the speed of light. In QED, it crops up as a plug to fill a gaping error in the virtual particle theory of electric force. Working through the concept of two electrons sending out quantum waves to seek each other's presence and then borrowing energy to form virtual photons, the resulting answer is $\frac{\hbar c}{r^2}$ some 137 too big when compared with the known answer of $\frac{e^2}{4\pi\,\varepsilon_0\,r^2}$. The ratio between these will of course be a dimensionless constant and lo and behold, it has all the right physical constants to be the fine structure constant $\alpha = \frac{e^2}{2\,\varepsilon_0\,h\,c}$. So by introducing this as a probability, the problem seems solved.

Many authors say that g is greater than 2 because of relativistic corrections. Since α is $\frac{v}{c}$ the relativistic corrections will be powers of $\gamma = \left(1 - \alpha^2\right)^{-\frac{1}{2}}$ which is far too small. However the term $\frac{v}{c}$ appears in electromagnetic theory when Gaussian or other mixed units are used. This is because the ratio between the size of certain units in esu and emu is the speed of light. The obvious example being the Lorentz force $\vec{E} + \frac{\vec{v}}{c} \wedge \vec{B}$.

Our analysis has shown that when the reduced mass model is used, the magnetic moment is calculated to be $\mu = n\frac{e}{m_r}\hbar$, but that when we use the real system, we get $\mu = \lambda\, n\frac{e}{m_e}\hbar$ where $\lambda = \frac{m_e}{m_p + m_e}$. Since the reduced mass $m_r = \lambda\, m_e$ the ratio between the two is λ^2. The inertial mass of the electron is subject to a relativistic mass increase by a factor γ.

We note the fact that: $\quad 2\left(\frac{m_p + m_e}{m_p}\right)^2\left(1 - \alpha^2\right)^{-\frac{1}{2}} = 2.002237...$

But this is inconclusive and the author is still pondering the matter and might even retain his faculties for another 34 years: the time it took the disciples of QED to calculate one of the terms in their series.